

ANSWERS: Properties of carbon compounds

1. (i) The boiling point of ethanol is higher than methanol, as there is one more carbon atom in ethanol than in methanol, so ethanol has a higher molar mass. As the molar mass increases, the forces of attraction (intermolecular force) between the molecules increase, so more energy is required to overcome these forces to form gaseous ethanol.

(ii) Methanol and ethanol are both soluble in water, as they are both alcohols and contain OH groups. The OH groups of the alcohols are attracted to water molecules. The alcohols are more attracted to the water molecules (e.g. methanol – water) than to each other (e.g. methanol – methanol), so they dissolve (accept evidence in a suitable diagram)

2. (i) gas

(ii) The boiling point of butane will be **higher** as there are more carbon (C) atoms than in propane (longer C chain). As the molar mass increases, the forces (intermolecular force) **between** the butane molecules / particles increases, so more energy is required to overcome these forces to form gaseous butane; so the boiling point is higher.

3. Covalent bonding occurs in organic compounds.

These organic compounds are made of carbon and hydrogen atoms, which are **non-metal atoms**. Non-metal atoms **share** their valence **electrons** to **gain full outer shells**, resulting in stable bonds. Sharing electrons in a bond is covalent bonding.

4. General formulae:

Alkanes (straight-chain) have the general formula C_nH_{2n+2} and alkenes have the general formula C_nH_{2n} .

Similarities and differences in chemical bonding:

In both alkanes and alkenes, the carbon and hydrogen atoms are **covalently bonded** to each other (could be from (b)). Alkanes are **saturated** hydrocarbon molecules, where **each carbon atom has four single covalent bonds**. Alkenes are **unsaturated** hydrocarbon molecules containing mostly single covalent bonds, but also a **carbon-carbon double bond**.

Chemical bonding linked to property and use:

Alkanes do **not have a functional group**, so they are generally **chemically unreactive / readily combust (property)**. Alkanes are commonly used as **fuels (use)**, because, while they are mostly unreactive, they do **undergo combustion reactions since single bonds do not require as much energy to break**. So a lot of energy is released as they combust.

The **double bond** in alkenes is a **functional group** and is **easily broken**, so alkenes are **chemically reactive (property)**. Since alkenes are chemically reactive, they can also undergo other chemical reactions, and are therefore commonly **used to make other organic molecules such as polymers (use) since the double bond easily breaks to form long chain**.

5. It is covalent bonding as it is made up of non-metal atoms C, H and O. Non-metal atoms share electrons to achieve full valence shells

6. Ethane has a lower melting / boiling point than ethanol because it has weaker attractions between the molecules, so does not need as much energy to boil.

Ethane is a gas at room temperature. Ethanol is a liquid at room temperature.

Ethane as a gas is not soluble in water, as there are no attractions between ethane and water.

Ethanol is an alcohol that is soluble in water because the (OH) part of ethanol is attracted to the water molecules.

7. As the number of carbon atoms in alkanes increases, the boiling point increases. As the mass of the molecules increases, more energy is needed to separate molecules / particles to change state. This factor causes the boiling points to rise.

Oil floats on top of the water because it is insoluble in water (immiscible), so will not dissolve in it. As the water molecules are more attracted to each other than they are to oil molecules, a layer of oil forms on top of the water.

The oil remains for a long time because it is insoluble in water, so the water cannot disperse it. It is also a saturated / unreactive molecule so difficult to remove with other chemicals.

8. Hexane has 6 carbons and is a bigger molecule, so it would be slightly harder to vaporise and therefore ignite and its size means it would likely burn with an orange flame producing soot. Hexane forms 2 layers when mixed with water (immiscible / insoluble) because there are no attractive forces between the water and the hexane molecules to allow solubility. Ethanol has only 2 carbons, so it is easy to ignite and will burn with an almost colourless flame. Ethanol is soluble (miscible) in water because there are attractive molecules between ethanol and water. Ethanol will boil before hexane as it has less mass and hence weaker attractive forces between the molecules.

9. Defining terms:

Melting point is the temperature at which a substance changes from a solid to a liquid.

Boiling point is the temperature at which a substance changes from a liquid to a gas.

Alkane states:

The alkane with three carbon atoms (propane) is a gas at room temperature and the one with six (hexane) is a liquid.

Particle behaviour:

When a solid melts, the particles which were in a fixed array gain enough kinetic energy to begin moving about freely, although they are still packed closely together.

When a liquid boils, the particles which were moving freely but packed close together gain enough kinetic energy to escape from the attractive forces on other particles and move about rapidly as well spread out gas particles.

Trends:

As the number of carbon atoms in the alkane molecules increases, the mass of the molecules increases. This increased mass means that more energy is required to free up particles in the solid state/ for particles to escape from the liquid state. This factor causes the melting/boiling points to rise.

10. As the size of the molecule increases, the temperature of the boiling point increases. This is because the molecules are getting bigger and the attractive forces between them are also getting bigger. This means more energy is required to break the intermolecular bonds.

11. ethanol

12. methanol

13. Chemical properties:

- Both liquids will undergo combustion reactions.
- Ethanol can be oxidized to ethanoic acid.

Physical properties:

- Hexane is immiscible in water, forming 2 layers, whereas ethanol is miscible in water forming a solution.
- Hexane is a bigger molecule than ethanol, but both have similar boiling points.
- Hexane is less dense than ethanol.

Distinguish by solubility in water, or by burning droplets on a spatula, or by finding the mass of the same volume of liquid, or by distilling under carefully controlled conditions (hexane bp 68.7 °C ethanol bp 78.3)

14. Propene and pentane